Copy to Bob Schneider FDL

County of Yolo

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April 19, 2005

Robert Schneider, Chairman
California Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive, #200
Rancho Cordova CA 95670

SUBJECT: Comments on Cache Creek, Bear Creek, and Harley Gulch TMDL for Mercury

Dear Chairman Schneider,

I am writing to provide you with recommendations and comments from the Yolo County Board of Supervisors on the Cache Creek, Bear Creek, and Harley Gulch TMDL for mercury. These comments are based on the work of County staff, consultants under contract with the County and the Yolo County Flood Control and Water Conservation District, and the Cache Creek Mercury Stakeholders Working Group (convened by County staff). Please keep in mind as you review these comments that our goal is to achieve the maximum benefits of the TMDL at the lowest cost. We share the Central Valley Regional Water Quality Control Board's (RWQCB) goal of reducing the accumulation of methylmercury in fish tissue because of potential harm to human health and wildlife.

Recommendations

1. The TMDL should focus on reducing mercury loads from abandoned mercury mines and geothermal sources in the upper watershed, not on regulating activities in the lower watershed that have little or no contribution to the problem. According to the RWQCB staff report, 15% of the ongoing mercury loading in Cache Creek can be directly attributed to the upstream mercury mines. 85% is attributed to unknown sources, although these sources are believed to be largely linked to historic mining activities in the upper watershed. There is little evidence of a significant contribution from current activities in the lower watershed.

2. Monitoring and remediation activities should be paid for by federal and state funds (not local funds), as the presence of mercury in Cache Creek and other California waterways is the result of historic mining activities and natural erosion from a mercury-enriched watershed. In addition, all taxpayers gain from efforts to understand and remediate mercury transport and bioaccumulation because of the benefits to human health and wildlife.

3. The TMDL should not adopt a numeric objective for methylmercury in fish tissue that is substantially more stringent than the new National Criterion for the Protection of Human Health. As you know, Cache Creek is one of the most mercury-impaired waterways in the United States with abandoned mercury mines, massive residual bed loads of mercury, and a mercury-

enriched upper watershed. Under these circumstances, it may be unrealistic – for the purposes of regulatory actions – to require an endpoint that is more stringent than the National Criterion. (See Darell Slotton's analysis of TMDL mercury criterion calculations for Cache Creek fish and water for more information, enclosed).

Comments

Monitoring and Remediation Requirements

1. It is our understanding that the proposed TMDL requires a monitoring program and/or mitigation program for any project that may potentially discharge sediment to the creek or any of its tributaries if the finest grained portion of that sediment (which contains the greatest mercury concentrations) has an average mercury or methylmercury content greater than 0.2 mg/kg, 0.5 mg/kg maximum. It is further our understanding that this level, for this sediment fraction, likely applies to virtually all sediments in the watershed. The RWQCB should consider revising this requirement to ensure that discharges of sediment are lower in mercury concentration than the receiving sediments of the creek. In such cases, the sediment is actually diluting the mercury level in the creek.

2. As stated in (1), it is our understanding is that any work, of any kind, that involves disrupting erodible soil or discharging water to the creek will trigger the monitoring and mitigation requirements in the proposed TMDL. The additional time and costs resulting from such requirements will dramatically delay or discourage wildlife habitat restoration, infrastructure maintenance, campground maintenance, bank stabilization, and other activities – for what appears to be very little benefit because of the relatively small contribution of such activities to the overall problem. Some of these activities may stop altogether because of the increased cost and workload. The RWQCB should clearly assess the benefits from regulating these activities before moving forward with the TMDL.

3. The TMDL is unclear as to whether the RWQCB plans to require ongoing mercury monitoring of the entire watershed. If so, the RWQCB needs to establish a coordinated, watershed approach to monitoring and should find federal and state funds to pay for it before requiring local entities to monitor for mercury. Towards that end, the RWQCB should also provide an estimate of the costs of a watershed-based approach to mercury monitoring. Our understanding is that samples for total mercury or methylmercury in water cost approximately $130/sample. Total mercury in sediment and fish samples cost $50/sample or more. Methylmercury in sediment and fish samples typically costs well over $100/sample. Such costs add up quickly, and these are only part of the costs of a monitoring program. The County, for example, spent over $100,000 for three years of mercury monitoring at the Cache Creek Nature Preserve and recently signed a contract for another $100,000 of monitoring. Such efforts cover only a very small area of the creek and more extensive monitoring could run into the millions of dollars.

4. It is our understanding from reviewing the data in the staff reports that the RWQCB staff only took samples of sediment from the creek bed, not from the creek banks, drainages, and washes that discharge to the creek and its tributaries. Yet the RWQCB is assuming that mercury levels in the creek can be reduced if activities that involve the creek banks, drainages,

and washes are regulated. The RWQCB should first collect information about the potential benefits of such regulations before requiring potentially costly monitoring and remediation activities.

5. It is our understanding that short of reducing sulfur loading from geothermal sources (if feasible) and mercury loading from abandoned mercury mines, alternatives to stop the methylation of mercury in the creek would involve some sort of sterilization of the creek because mercury methylation is a natural byproduct of the functioning of a normal, healthy ecosystem. The RWQCB would have to remove sediment, organic matter, and biota to stop it, which would be very detrimental to the ecosystem.This is obviously an unrealistic approach. If the RWQCB's focus is only on preventing additional methylation in the creek by reducing additional loading of inorganic mercury, it should be clearly stated in the TMDL.

6. The RWQCB states that the watershed above Rumsey is the major source of methylmercury and total mercury. The RWQCB should state clearly in the TMDL that it will focus its regulatory efforts on the watershed above Rumsey, not on the lower watershed. The TMDL currently mandates the same requirements for activities in the upper watershed and the lower watershed. As stated previously, the County believes that the RWQCB should focus its efforts on reducing mercury loadings from abandoned mercury mines and geothermal sources in the upper watershed.

7. The TMDL currently seems to require local jurisdictions and individuals to control naturally-occurring discharges of mercury to the creek. If this is not the case, the TMDL should clarify so as to avoid any interpretation to the contrary in the future.

Numeric Objectives

8. The TMDL does not clearly show how sediment and water discharges into the creek will be connected to the numeric objectives of 0.12 mg/kg and 0.23 mg/kg for trophic level 3 and 4 fish, respectively. It is our understanding that science cannot yet accurately predict how discharges of mercury into the creek impact the methylmercury concentration in fish tissue. Sediment and water discharges to the creek should not be regulated if the RWQCB cannot demonstrably show that these discharges are a significant contributor to the problem of high levels of methylmercury in fish tissue.

9. The proposed TMDL identifies representative fish species for each trophic level:

   - Trophic level 3: green sunfish, bluegill, and/or Sacramento sucker (rainbow trout also an option for North Fork Cache Creek); and

   - Trophic level 4: Sacramento pikeminnow, largemouth bass, smallmouth bass and/or channel catfish (p. 15).

   Green sunfish do not belong in the same trophic category as fish like bluegill and Sacramento sucker. Green sunfish are not large but they are piscivores (fish eaters) that develop mercury

levels more similar to bass, catfish, and crappie. Their inclusion in the lower trophic level could lead to false apparent exceedences, relative to Trophic level 3.

10. The proposed TMDL states that the sample sets should include at least two species from each trophic level (i.e. bass and Sacramento pikeminnow, for Trophic level 4) collected at each compliance point or stream section (p. 15). Proposed requirements for extensive collections of two different species of Trophic level 4 fish and two types of Trophic level 3 fish at each monitoring site may be unrealistic. Intensive sampling efforts throughout the watershed during a UC Davis research project resulted in difficulty obtaining adequate samplings of just one representative of each trophic level and only rarely found two readily available Trophic level 4 species at any single location. This niche was typically occupied by one of the following species at each site: smallmouth bass, largemouth bass, or Sacramento pikeminnow.

11. The proposed TMDL also states that the samples should include a range of sizes of fish between 250 and 350 mm, total length (p. 15). The size requirements do not always make sense. In the case of the two sunfish species (green sunfish and bluegill), the 250-350 mm range is larger than typical fish in the population.

12. The proposed TMDL states that the proposed concentrations in fish would protect the federally listed bald eagle (p. 24). It also appears that the 0.12 and 0.23 mg/kg target levels are based primarily on the bald eagle. It should be established what proportion of the year bald eagles fish in Cache Creek, in relation to nesting and raising of young. Mercury ingested from the watershed by adults could be a problem for young, even if they are raised at another location (through some egg transfer of mercury), but the criterion considerations are likely based on the assumption of local nesting and rearing of young eagles on a diet of Cache Creek fish. It seems that more research is needed to determine if eagles that winter seasonally in the Cache Creek canyon are impacted by mercury, especially since evidence suggests that the population is expanding.

13. According to the proposed TMDL, "The initial USEPA methylmercury criteria report did not describe how the criterion should be applied to fish species with different concentrations of methylmercury. The USEPA recommends, however, that the criterion be applied using information about local consumption. Most of the fish caught and kept from Cache or Bear Creeks are Trophic level 4 fish, such as catfish, bullhead, pikeminnow, and bass. Some trophic level 3 species, such as bluegill, may also be caught and kept for consumption (CDFG, 2004c; observations by Regional Water Board staff). Humans are unlikely to consume trophic level 2 fish from Cache or Bear Creeks. *A logical way to interpret the USEPA criterion for Cache and Bear Creeks, then, is to assign the criterion of 0.3 mg/kg as the average concentration of methylmercury in locally caught trophic level 4 fish. This interpretation still assumes a consumption rate of 17.5 g/day, but accounts for the local situation that most fish consumed are trophic level 4 species."* In the discussions of Alternative 3, the National Criterion of 0.30 mg/kg is presented in a substantially more restrictive interpretation than presented by the USEPA. The USEPA criterion assumes a mixture of species and trophic levels in the average fisherman's catch. The 0.30 mg/kg protective concentration level is clearly defined by the USEPA as being the *average* of mercury concentrations among all of the trophic levels contained in a typical mixed-bag catch. The modest level of consumption fishing along Cache Creek includes carp,

sunfish, and small trophic level 4 fish, in addition to larger trophic level 4 fish. The fish tissue criteria calculations are discussed in much greater detail in the enclosed analysis entitled "Analysis of TMDL Mercury Criterion Calculations for Cache Creek Fish and Water."

14. According to the proposed TMDL, "The goals of all of the proposed water quality objectives and the control program are to return mercury levels in fish tissue to levels that occurred in the pre-mining period and to remediate mercury sources contributing to the mercury impairment. Regional Water Board staff considered providing the pre-mining condition as an alternative, but was unable to determine the pre-mining fish tissue concentrations of methylmercury. The proposed tissue and sediment concentrations are expected to result in fish tissue concentrations that would approach a natural background level." The TMDL does not appear to follow through with this reasoning. For this particular watershed, which is naturally highly enriched in mercury, including documented major mercury inputs from geothermal springs, the natural background level was likely never pristine and likely never will be. This should be taken into account in setting realistic goals and setting site-specific objectives.

15. According to the proposed TMDL, "Wintering bald eagles feeding in Cache and Bear Creeks consume almost exclusively large, non-game fish species (USBLM, 2002; Slotton et al., 2004). Nesting by bald eagles in the Cache canyon has been observed since 2000 (USBLM, 2002)." An eagle-based criterion should be based on fish typically eaten by Cache canyon eagles, i.e. adult Sacramento suckers. The corresponding acceptable concentration in trophic level 4 fish (one of the primary targets for proposed monitoring and compliance) would be substantially greater than the acceptable concentration in the eagle diet.

16. According to the proposed TMDL, "Although the Alternative 3 proposed fish tissue objectives are higher, the control program needed to achieve the objectives would be essentially the same for Alternatives 2 and 3. This is because the aqueous methylmercury concentrations that correspond to the fish tissue objectives are nearly identical: 0.06 ng/L methylmercury to achieve Alternative 2 in Cache and Bear Creeks and 0.07 ng/L to achieve Alternative 3." As above, this is based on a presentation of Alternative 3 that assumes people catch and consume entirely large, top predator fish of trophic level 4. It also interprets the UC Davis research on aqueous versus biotic mercury in a way that includes large levels of uncertainty. An alternative, direct approach based on the field research indicates protective water concentrations that are approximately 5 times higher than the criterion levels proposed as Alternative 3 (0.07 ng/liter) or Alternative 2 (0.06 ng/liter). This is discussed at length in the separate analysis document.

17. According to the proposed TMDL, "the recommended objectives protect a slightly higher proportion of the fish-consuming population than would be protected by Alternatives 3, which is based on USEPA's default consumption rate for the general population (p.36)." The recommended objective (Alternative 2) appears to be only slightly different than Alternative 3 because Alternative 3 assumes that all of the fish caught and consumed from Cache Creek are large individuals of top predator, trophic level 4 species. If Alternative 3 was in fact based on USEPA's default consumption rate for the general population, it would be substantially less restrictive than Alternative 3 as presented. As calculated in the companion analysis, Alternative 3, using the national default consumption rates, was found to result in Criterion-equivalent concentrations of 0.25 mg/kg for Trophic level 3 fish and 0.48 mg/kg for Trophic level 4 fish, as

compared to 0.15 mg/kg and 0.30 mg/kg as presented, and as compared to the proposed (Alternative 2) levels of 0.12 and 0.23 mg/kg.

18. According to the proposed TMDL, "None of the proposed water quality objectives would restrict the development of housing in the Cache Creek watershed (p. 30)." As stated, all earth-moving operations anywhere in the valley or adjacent to the creek or a tributary would be subjected to the substantial additional costs of developing a mercury mitigation plan and conducting associated monitoring. It is our understanding that reference to the 100-year floodplain will be removed from the document. We suggest that the TMDL limit its scope to the immediately adjacent lands that may result in mercury discharges to the creek and that the focus should be on reducing mercury loadings from abandoned mercury mines and geothermal sources in the upper watershed.

Beneficial Uses

19. The proposed TMDL adds commercial and sport fishing to the beneficial uses of Cache Creek (p. 6). The proposed TMDL also bases its criterion for methylmercury in fish tissue on assumptions about the number of fish that wildlife and humans eat from Cache Creek. The RWQCB staff stated at the March 18, 2005 meeting that there is not a commercial fishery on Cache Creek, but that there is a sport fishery. Additional information is needed before sports fishery is added as a beneficial use, and before assumptions are made about the number of fish that people and wildlife catch and eat from Cache Creek. Our understanding is that the actual amount of fishing, and in particular, consumption of fish caught in the Cache Creek watershed has never been studied and warrants additional investigation. The County is posting warning signs along Cache Creek to prevent consumption of contaminated fish, despite the lack of information about fishing.

20. The existing and potential beneficial uses of Cache Creek and its tributaries are listed in Table 3.1 of the proposed TMDL. In addition, staff is proposing to add the COMM beneficial use to Cache Creek (including North Fork) and Bear Creek. Three existing beneficial uses, Municipal Supply, Recreation 1 and Wildlife Habitat, are considered impaired due to mercury. The COMM beneficial category remains questionable and it is not clear how adding that category results in any further improvements. It is already stated that "Recreation 1" is impaired due to mercury. This is assumed to refer specifically to fishing benefits, as it would be incorrect to imply that other recreational benefits (e.g. swimming, rafting, etc.) are impacted due to mercury.

Consistency with Other Regulations

21. As long as gravel companies conducting operations approved under Yolo County's off-channel mining plan are not discharging into the creek, the TMDL should specifically state that they are exempt from the TMDL requirements.

22. The RWQCB staff should make sure that the TMDL is consistent with other existing regulations, such as erosion control plans, stormwater regulations, and others. Our understanding is that other regulations are required to be consistent with the TMDL, once finalized, but there could

be efficiency losses and unintended consequences if the TMDL is developed without regard to existing regulations.

23. The TMDL currently seems to consider irrigation drainage into the creek as a potential source of mercury subject to the requirements of the TMDL. The TMDL should specify how the mercury TMDL and the ongoing Ag Waiver Monitoring Program in Yolo County will be coordinated.

24. According to the proposed TMDL on p. 32, "The federal antidegradation policy applies if a discharge or other activity, which began after 28 November 1975, will lower surface water quality." In relation to the proposed language regarding water and sediment discharges, this federal clause provides a precedent for *not lowering surface water quality*, as opposed to proposed language that implies a disallowance of flows that could be relative dilutions to existing water/sediment quality. Furthermore, the intent of the federal degradation policy is to protect existing high quality waters, so it is unclear how the RWQCB plans to apply the policy to Cache Creek.

Thank you for the opportunity to comment.

Sincerely,

Helen M. Thomson
Chairwoman, Yolo County Board of Supervisors

Analysis of TMDL Mercury Criterion Calculations for Cache Creek Fish and Water

Darell Slotton for Yolo County

4/3/05

Summary

At the request of Yolo County, the proposed TMDL document and associated Staff Report of the Regional Water Quality Control Board (RWQCB) for mercury in Cache Creek were reviewed. The focus of this section is the specific criterion concentrations presented for fish and water. Review has concluded that the proposed fish criterion concentrations for the protection of human and wildlife health are substantially more restrictive than the intent of the EPA National Criterion for mercury. It was also concluded that associated proposed target concentrations for methylmercury in water are approximately five-fold more restrictive than those corresponding to fish mercury levels protective of human and wildlife health for Cache Creek.

The human health considerations, as presented in the TMDL, assume that people catch and consume only the very most contaminated fish—large individuals of the top predator species such as bass. The National Criterion, however, assumes that people catch and consume a variety of fish sizes and types, with the 0.30 ppm criterion representing the *average* mercury concentration. The proposed TMDL presents levels of 0.15 ppm for trophic level 3 fish (TL3) and 0.30 ppm for trophic level 4 fish (TL4) as corresponding to the National Criterion for the Protection of Human Health (Alternative 3). In contrast, when Cache Creek fish are considered in a way consistent with the National Criterion, protective concentrations in TL3 fish are calculated to range from 0.21-0.25 ppm and in TL4 fish from 0.39-0.48 ppm. For people who do not additionally consume commercial fish, the protective levels are 33% higher.

The recommended Alternative 2 (0.12 ppm TL3 and 0.23 ppm TL4), is more restrictive than Alternative 3 and is based on wildlife considerations, particularly the two federally listed threatened species known to be present in the watershed during some parts of the year, bald eagles and peregrine falcons. Problems were found in the calculations of protective mercury levels in the prey of these species. When these were adjusted, based on existing data, protective fish mercury concentrations in the creek were found to be similar to those recalculated for protection of human health, approximately double the proposed fish criterion concentrations.

The target concentration for methylmercury in water was based on corresponding fish mercury levels. When a direct comparison was made, based on extensive existing data, the water concentration of methylmercury in Cache Creek corresponding to acceptable fish mercury levels was found to be approximately five-fold higher than the proposed target concentration.

As the proposed new mercury criterion concentrations for Cache Creek will be the primary basis for regulatory and management actions, these discrepancies could be important in re-assessing the magnitude and, particularly, the focus of mercury regulation and management in the creek.

Below, the math and derivations behind the human health criteria, wildlife health criteria , and linkage to water methylmercury concentrations are examined in detail.

National Criterion calculations relating to Alternative 3 (Human Health):

In the discussions of Alternative 3, the National Criterion of 0.30 ppm is presented in a substantially more restrictive interpretation than presented by the US EPA. The EPA criterion assumes a mixture of species and trophic levels in the average fisherman's catch. The 0.30 ppm protective concentration level is defined by the EPA as being the *average* mercury concentration among all of the trophic levels contained in a typical mixed-bag catch. EPA provides trophic breakdown proportions for a standard angler's catch consumption, based on national averages from extensive censusing. This default, census-based, national average is composed of approximately 21% trophic level 2 fish (TL2), 46% trophic level 3 fish (TL3), and 33% trophic level 4 fish (TL4). EPA also encourages the determination of a locally-based estimate of a typical angler's catch trophic breakdown. As the Criterion concentration, whether using the national default or locally derived catch proportions, is based on an average across the typical trophic levels consumed, it assumes concentrations less than 0.30 ppm in the lower trophic levels and concentrations greater than 0.30 ppm in the TL4 fish. A Cache Creek criterion of 0.30 ppm for the top predator (most contaminated) fish, as presented, would be considerably more restrictive than the National Criterion, which assumes an *average* concentration of 0.30 ppm among the mixed trophic levels present in a typical catch.

The Board indicates that there are no trophic level 2 fish in the watershed for people to potentially eat and, therefore, the calculations corresponding to the National Criterion should omit this component which accounts for 21.7% of the typical angler diet nationwide. It is unclear if this is the case and this should be re-examined. We have seen people specifically target carp. It is also important to note, for the wildlife section, that if there are assumed to be no large TL2 fish in this watershed, there should be few or no small TL2 fish either, and it would be unrealistic to base the wildlife exposure calculations specifically on small TL2 fish as was done.

The Board's presentation of the National Criterion for Human Health (0.30 ppm, average concentration among a typical mixed catch for people who also consume 12.5 g/day commercial fish) does not include calculations of corresponding mercury concentrations in specific fish types. The National Criterion for the Protection of Human Health should be an important benchmark option under consideration; calculations of this level should be carefully examined.

The National Criterion is based on these national averages:

- The standardized angling-related diet is defined as the consumption rate of angling catch by the 90^{th} percentile of people, which national censusing found to be 17.5 g/day.

- The typical angling-related catch consumption is composed of different trophic level fish in the following proportions: 21% TL2 fish, 46% TL3 fish, and 33% TL4 fish.

- The average consumer is estimated to additionally consume 12.5 g/day of commercial fish, which also contains some methylmercury.

- 0.30 ppm (the Criterion level) = the safe average Hg concentration of angling catch, for people that additionally consume the national average 12.5 g/day of commercial fish.

- 0.40 ppm = the equivalent Criterion safe average Hg concentration of angling catch, for people that obtain all of their methylmercury from locally caught fish.

Here is the basic National Criterion equation:
0.30 = (21% x TL2conc) + (46% x TL3conc) + (33% x TL4conc)

This equation can be used to determine the acceptable Hg concentrations corresponding to the National Criterion for each fish trophic level. The Board proposes to implement the TMDL based on concentrations in, particularly, adult TL3 and TL4 fish, so calculations of Criterion-equivalent concentrations for these groups are critical.

There are three unknowns in this equation: TL2conc, TL3conc, and TL4conc.
To solve this type of algebra equation, it is necessary to convert the different unknowns into terms of one single unknown. To do this, we need estimates of the ratios of typical Hg concentrations in angling-size fish of the different trophic levels. This is exactly the approach the Board uses in the presentation of wildlife criteria. The ratio used by the Board for angling-relevant TL4 fish to TL3 fish is 1.9, based on data collected throughout the Delta region. This ratio means that, on average, the mercury concentrations of TL4 fish at a given site are approximately 1.9x greater than the concentrations in same-site TL3 fish. No ratio was available for regional TL3 fish to TL2 fish of angling size, so a similar ratio will be used (also 1.9), meaning that, on average, TL4 fish contain 1.9x greater mercury concentrations than TL3 fish, which contain 1.9x greater levels than TL2 fish. The unknowns can now all be put in terms of TL2 as follows:
TL2 = TL2
TL3 = TL2 x 1.9
TL4 = TL2 x 1.9 x 1.9 = TL2 x 3.61

Putting these replacements into the original equation gives this solvable equation:

0.30 ppm = (21% x TL2conc) + (46% x TL2conc x 1.9) + (33% x TL2conc x 3.61)

which simplifies to:
0.30 ppm = TL2conc x [(0.21) + (0.46 x 1.9) + (0.33 x 3.61)]

which simplifies to:
0.30 ppm = TL2conc x [(0.21) + (0.87) + (1.19)]

which simplifies to:

0.30 ppm = TL2conc x 2.27

Rearranged:
TL2conc = 0.30 ppm / 2.27

which simplifies to:
TL2conc = 0.132 ppm

This corresponds to the following criterion-equivalent concentrations:
TL2conc = 0.132 ppm
TL3conc = 0.132 x 1.9 = 0.251
TL4conc = 0.132 x 1.9 x 1.9 = 0.477

Reduced to 2 significant figures:
TL2conc = 0.13 ppm
TL3conc = 0.25 ppm
TL4conc = 0.48 ppm

In other words, using the 0.30 ppm mixed-catch National Criterion, together with the national default trophic catch proportions and inter-trophic ratios of 1.9 for co-occurring large fish, these above concentrations would correspond to the National Criterion for the Protection of Human Health for Cache Creek angling-sized fish. A standard mixed-catch with these concentrations would have a mean concentration of 0.30 ppm, protective of human health. These standards (0.25 ppm for TL3 fish and 0.48 ppm for TL4 fish) would be far more attainable than either the 0.12 and 0.23 ppm target levels proposed (Alternative 2) or the 0.15 and 0.30 ppm levels presented as corresponding to the National Criterion (Alternative 3).

For people who do not additionally consume commercial fish, these concentrations would be protective:
TL2conc = 0.18 ppm
TL3conc = 0.33 ppm
TL4conc = 0.64 ppm

The Board assumes that no TL2 fish are consumed in the Cache Creek watershed and discusses scenarios for these alternate proportions in the typical angler's catch:
100% TL4 fish
50% TL3 fish and 50% TL4 fish
(both with and without additional consumption of commercial fish)

This is in contrast with the national census data which found 33% of the typical angling diet to come from TL4 fish and 67% to come from TL2 and TL3 fish.

The National Criterion concentrations corresponding to the Board scenarios are:

If 100% TL4 fish, plus 12.5 g/day commercial fish:
TL4conc = 0.30 ppm
(This is the basis for the Board's presentation of Alternative 3)

If 100% TL4 fish, without commercial fish:
TL4conc = 0.40 ppm

If 50% TL3 fish, 50% TL4 fish, plus 12.5 g/day commercial fish:
0.30 ppm = (0.5 x TL3conc) + (0.5 x TL3conc x 1.9)
0.30 ppm = TL3conc x [(0.5 + (0.5 x 1.9)]
0.30 ppm = TL3conc x [(0.5 + (0.5 x 1.9)]
0.30 ppm = TL3conc x 1.45
TL3conc = **0.21 ppm**
TL4conc = 0.21 x 1.9 = **0.39 ppm**

If 50% TL3 fish and 50% TL4 fish, without commercial fish:
0.40 ppm = (0.5 x TL3conc) + (0.5 x TL3conc x 1.9)
0.40 ppm = TL3conc x [(0.5 + (0.5 x 1.9)]
0.40 ppm = TL3conc x [(0.5 + (0.5 x 1.9)]
0.40 ppm = TL3conc x 1.45
TL3conc = 0.28 ppm
TL4conc = 0.28 x 1.9 = 0.52 ppm

Table 1, below, summarizes the range of concentrations that correspond to the National Criterion for the Protection of Human Health, depending on the percentages used to estimate the proportions of different trophic levels in a typical catch, with and without additional commercial fish, and as compared to the Board Alternatives and the revised Wildlife Criteria from the following section.

Table 1. Mercury concentrations (ppm = mg/kg = µg/g) in trophic level 3 (TL3) and trophic level 4 (TL4) fish, corresponding to the National Criterion for the Protection of Human Health, using different estimates of relative proportions of each trophic level in standard angling consumption. Board Alternative Criteria 2 and 3 and revised Wildlife Criteria from the next section are included for comparison.

Criterion and Catch Proportion Assumptions	*TL3 Fish*	*TL4 Fish*
National Criterion, using national averages: 21% TL2 fish, 46% TL3 fish, 33% TL4 fish, without additional commercial fish	0.33	0.64
National Criterion, using national averages: 21% TL2 fish, 46% TL3 fish, 33% TL4 fish, including 12.5 g/day commercial fish	**0.25**	**0.48**
National Criterion, 50% TL3 fish, 50% TL4 fish, without additional commercial fish	0.28	0.52
National Criterion, 50% TL3 fish, 50% TL4 fish, including 12.5 g/day commercial fish	**0.21**	**0.39**
National Criterion, 100% TL4 fish, without additional commercial fish		0.40
National Criterion, 100% TL4 fish, including 12.5 g/day commercial fish		0.30
Board Alternative 3 (presented as the National Criterion)	0.15	0.30
Board Alternative 2 (presented as eagle-protective)	0.12	0.23
Revised Wildlife Criteria, protective of federally listed bald eagles and peregrine falcons (next section)	**0.19**	**0.45**

Wildlife Protective Calculations:

As with the human-protective calculations, the wildlife equations work backward from a literature-derived safe dietary mercury concentration for each species. These concentrations are functions of (1) published safe reference doses (RfD) in units of micrograms of dietary mercury per kg animal body weight, (2) typical body weight of animal, and (3) total food ingestion rate (grams per day). The RfD is multiplied by the body weight to calculate the total micrograms of methylmercury that can safely be consumed per day. This is then divided by the average grams of food consumed per day to obtain a safe average mercury concentration for the animal's food. These data are presented in Table 2.2 of the Cache TMDL. They appear to be realistic numbers based on the best available data.

In the next step, the calculated safe whole-diet mercury concentration is partitioned into the various diet items of the animal, as was done in the human-protective calculations. Each diet item is weighted by (1) its percent mass in the total diet and (2) a mercury concentration ratio between the item and one of the other items, used to solve the resulting algebra equation. As seen for the human-protective calculations, the ultimate results can vary substantially, depending on the ratios used.

Bald eagles are the focus of the Board Staff Report's considerations of a more restrictive wildlife-protective criterion in place of a human-protective criterion for mercury. The rationale for this is their federally listed threatened status, combined with their largely aquatic diet and significant seasonal presence in the upper watershed.

This is the equation that was used to partition the predicted food items of Cache Creek bald eagles by weight proportion in the diet:

0.195 mg/kg (the safe whole diet Hg concentration) = (0.58 x TL3conc) +
(0.13 x TL4conc) +
(0.13 x OBconc) +
(0.05 x PBconc)

This corresponds to a diet of 58% TL3 fish, 13% TL4 fish, 13% omnivorous birds, and 5% piscivorous birds. An additional 11% of the diet is estimated to be from animals with insignificant mercury levels (such as squirrels).

These percentages are estimates based on other regions and may not represent the actual diet proportions of bald eagles that forage in the Cache Creek canyon. In a bald eagle dietary study conducted in other parts of Northern California, the following ratios were reported for mercury-relevant eagle diet items:

(0.632 x TL3 fish)
(0.078 x TL4 fish)
(0.077 x Piscivorous Birds)

It is not clear that TL4 fish, piscivorous birds, or omnivorous birds are significant food items for bald eagles that forage in the Cache canyon. Observations of that population indicate that their primary targets are adult Sacramento suckers and carp.

Returning to the equation:

0.195 mg/kg (the safe whole diet Hg concentration) =	(0.58 x TL3conc) +	
	(0.13 x TL4conc) +	
	(0.13 x OBconc) +	
	(0.05 x PBconc)	

In order to solve the algebra problem with 4 food items and 4 variables, it is necessary to use multipliers to convert the different variables into terms of just one variable. These multipliers represent the predicted ratio of mercury concentrations between trophic categories. The Board used the following multipliers in the bald eagle calculations:

0.195 mg/kg (the safe whole diet Hg concentration) =	(0.58 x TL2conc **x 5.7**)	(TL3 fish)
	(0.13 x TL2conc **x 11.4**)	(TL4 fish)
	(0.13 x TL2conc **x 10.0**)	(Omn. Birds)
	(0.05 x TL2conc **x 71.25**)	(Pisc. Birds)

Reducing:

0.195 mg/kg (the safe whole diet Hg concentration) =	(TL2conc x 3.31)	(TL3 fish)
	(TL2conc x 1.48)	(TL4 fish)
	(TL2conc x 1.30)	(Omn. Birds)
	(TL2conc x 3.56)	(Pisc. Birds)

Reducing:

0.195 mg/kg (the safe whole diet Hg concentration) =	(TL2conc x 9.65)	(All 4 items)

0.195 / 9.65 = TL2conc
TL2conc = 0.020 mg/kg or ppm

This calculated TL2conc result is then used to predict corresponding safe concentrations in the bald eagle diet items, again using the inter-trophic mercury multipliers:
TL3conc = 0.020 x 5.7 = **0.12 ppm**
TL4conc = 0.020 x 11.4 = **0.23 ppm**
OBconc = 0.020 x 10.0 = 0.20 ppm
PBconc = 0.020 x 71.25 = 1.45 ppm

These calculated concentrations are the basis for the proposed Alternative 2 criteria. It can be seen from the above equations that the two multipliers assigned to each eagle food item (the estimated weight percentage in the diet and the inter-trophic mercury multiplier) directly influence the calculated results. Some of these multipliers appear to be incorrect.

First, there may be problems associated with the estimated weight percentages assigned to the various potential food items in the Cache bald eagle diet. In the above equations, this diet mix assigns 18.3%, by weight, of the eagle fish consumption to TL4 fish (vs 11% in the Northern California eagle study). From the above equations, the percentages of total daily eagle dietary methylmercury corresponding to each food type are:

TL3 fish: 3.31 / 9.65 = 34.3%
TL4 fish: 1.48 / 9.65 = 15.3%
Omnivorous birds: 1.30 / 9.65 = 13.5%
Piscivorous birds: 3.56 / 9.65 = 36.9%

This means that the Alternative 2 criterion concentrations are based on Cache Creek bald eagles obtaining 31% of their fish-based methylmercury from TL4 fish [(15.3% / (34.3% + 15.3%)] and 50.4% of their overall methylmercury from consumption of omnivorous and piscivorous birds. It is not clear that these food items are significant in the diet of the Cache canyon seasonal eagle population. As noted above, the primary targets of these birds appear to be adult Sacramento suckers and carp.

The most serious problems, however, relate to the inter-trophic multipliers.

The wildlife calculations place all of the food variables into terms of small TL2 fish. In the human health sections, the Board indicates that there are no TL2 fish in the watershed. The Staff Report also notes that small TL2 fish are not part of the bald eagle diet. Using predicted concentrations of methylmercury in small TL2 fish as the basis for calculations adds a large degree of uncertainty. The calculations use a multiplier of 5.7x the predicted small TL2 fish concentrations to estimate the corresponding concentrations of methylmercury in large TL3 fish. A further multiplier of 2.0x is used to estimate the corresponding methylmercury concentrations in large TL4 fish, slightly greater than the 1.9x multiplier used in the human-protective calculations.

The omnivorous and piscivorous bird multipliers (10x and 71.25x the predicted small TL2 fish mercury concentrations, respectively) are particularly questionable. The omnivorous bird category was added in the most recent draft of the TMDL. As stated in the reports, "the omnivorous birds of concern in the bald eagle diet feed on trophic level 2 aquatic prey (mostly invertebrates)." This recognizes that, in addition to fish-eating birds like mergansers and grebes, waterfowl that dabble for small invertebrates can provide another, more minor source of dietary methylmercury to eagles if part of their diet. The omnivorous bird trophic mercury multiplier is presented as the ratio between the omnivorous birds and "small TL2/3 prey fish and other aquatic organisms." As this ratio is presented as a food chain multiplier (FCM), intended to represent the Hg concentration ratio between consumer and prey, it should actually be estimated in relation to the mixed plant material and small invertebrates that make up the typical diet of these birds. The typical duck or coot diet should be considerably lower in methylmercury than co-occurring small TL2/3 fish. Additionally, a 10x FCM between consumer and prey is unusually large and should be re-examined. Ratios in the range of 5x are more typical; thus omnivorous bird methylmercury should be expected to be approximately 5x the average methylmercury concentration in their mixed plant and invertebrate diet.

For the potential piscivorous bird portion of the eagle diet, an FCM of 12.5 is applied between these mergansers, grebes, etc. and their presumed small TL3 fish prey. Again, this is an unusually large FCM between consumer and prey and should be carefully re-examined. In addition to the very large 12.5x FCM multiplier, the piscivorous bird component is multiplied by an additional 5.7x factor, leading to a total multiplier of 71.25x. The second multiplier (5.7x) is

presented as the ratio between methylmercury concentrations in *large TL3 fish* and small TL2 fish. But the first multiplier (12.5x) is in relation to *small* TL3 fish. A ratio of 5.7 may greatly overestimate the relation between small TL3 fish and small TL2 fish.

All of these ratios are based on the assumption of an equilibrium relationship between consumer and prey. This is likely the case for some local herons and kingfishers which are year-long residents, but not for waterfowl, which are almost entirely seasonal winter migrants in the Cache watershed. Over 15 years of waterfowl censusing in the Davis Creek portion of the watershed, near where the eagles winter, found the great majority of the waterfowl to reside there for only 1-3 months per year, typically within the period between November and March. Bird observations over numerous kayak trips through the Cache canyon in all seasons are consistent with this. These birds' methylmercury concentrations are determined by their diet across their life spans, almost certainly dominated by prey taken in locales considerably less Hg-impacted than Cache Creek. Applying 10x and 71.25x multipliers in relation to Cache Creek small TL2 fish (which themselves are not believed to be present in the watershed) appears to be inappropriate.

A suggested alternative approach would be to base the trophic mercury ratios on potential diet items that are known to be prevalent in the watershed, important in the eagle diet, and likely to be used in criterion monitoring. UC Davis collected a fairly extensive data set of time-linked samples of the primary predatory aquatic insects, small fish, large TL3 fish, and large TL4 fish present at sites throughout the watershed. This included a variety of small TL2/3 fish species that exhibited similar mercury levels, large Sacramento suckers (representing TL3), and the primary large TL4 fish of each site: smallmouth bass, largemouth bass, or Sacramento pikeminnow. Relationships between these groups were determined by comparing the adult fish concentrations directly and by comparing them, in turn, to the small fish by averaging the temporally variable small fish concentrations across the annual cycle at each site. In this way it was possible to derive correlations between these fish (and invertebrate) trophic levels specific to the watershed. The reduced data were presented in Table 6 of the UC Davis report; corresponding inter-trophic ratios are presented below in Table 2.

Table 2. Mercury concentration ratios between time-linked samples of fish taken in the Cache Creek watershed by UC Davis. Based on data sets including over 200 individual adult fish samples and several hundred multi-individual small fish samples.

Cache Watershed Sites	*Adult Sucker / Sm TL2/3 Fish Ratio*	*Adult TL4 Fish / Adult Sucker Ratio*	*Adult TL4 Fish / Sm TL2/3 Fish Ratio*
North Fork Cache Creek	1.23	2.77	3.41
Cache Creek below Clear Lake	3.44	1.56	5.38
Cache Creek at Rumsey	2.54	2.83	7.20
Cache Creek below Yolo	2.12	*(no TL4 sample)*	
Cache Creek below Hwy 505	1.82	2.62	4.77
Upper Bear Creek	2.57	2.37	6.09
Mid Bear Creek	3.00	1.85	5.55
Mean Ratios:	**2.39**	**2.34**	**5.40**

In the case of the bald eagles, which are the greatest focus of the wildlife criterion considerations, it is suggested that the trophic equation be solved for the variable that is most representative of their local diet, adult Sacramento suckers (nominally TL3). Suggested replacement inter-trophic mercury concentration multipliers are:

TL3 fish concentration = TL3conc

TL4 fish concentration = TL3conc **x 2.34** (from Table 2 above)

Omnivorous bird concentration = TL3conc **x 0.5**
Rationale: the diet of these birds, when they are present in the watershed, is estimated to be similar to that of the large suckers, which would lead to a multiplier of 1.0. Their typical short residence time in the Cache watershed is accounted for by reducing the multiplier by 1/2.

Piscivorous bird concentration = TL3conc **x 1.17**
Rationale: the diet of these birds, when they are present in the watershed, is estimated to be similar to the diets of large TL4 fish, which would lead to a multiplier of 2.34. Their typical short residence time in the Cache watershed is accounted for by reducing the multiplier by 1/2.

Returning to the bald eagle equation:

0.195 mg/kg (the safe whole diet Hg concentration) =	(0.58 x TL3conc) +	(TL3 fish)
	(0.13 x TL4conc) +	(TL4 fish)
	(0.13 x OBconc) +	(Omn. birds)
	(0.05 x PBconc)	(Pisc. birds)

Converting all to terms of TL3conc:

0.195 mg/kg (the safe whole diet Hg concentration) =	(0.58 x TL3conc)	(TL3 fish)
	(0.13 x 2.34 x TL3conc)	(TL4 fish)
	(0.13 x 0.50 x TL3conc)	(Omn. birds)
	(0.05 x 1.17 x TL3conc)	(Pisc. birds)

Reducing:

0.195 mg/kg (the safe whole diet Hg concentration) =	(0.58 x TL3conc) +	(TL3 fish)
	(0.30 x TL3conc) +	(TL4 fish)
	(0.07 x TL3conc) +	(Omn. birds)
	(0.06 x TL3conc)	(Pisc. birds)

Reducing:

0.195 mg/kg (the safe whole diet Hg concentration) = 1.01 x TL3conc

TL3conc = 0.195 / 1.01 = 0.193 (**0.19**)
TL4conc = 0.193 x 2.34 = 0.452 (**0.45**)

This means that, using the Board's eagle diet proportions, together with the revised inter-trophic mercury multipliers, concentrations of 0.19 ppm in adult Sacramento suckers and 0.45 ppm in adult TL4 fish of the Cache watershed would be protective of bald eagles. These levels are similar to those corresponding to the National Criterion for the Protection of Human Health.

For the remaining federally-listed threatened species that can be found seasonally in the watershed, peregrine falcon, the mercury-relevant diet equation is:

0.139 mg/kg (the safe whole diet Hg concentration) =	(0.10 x OBconc) +	(Omn. birds)
	(0.05 x PBconc)	(Pisc. birds)

Solving in terms of adult TL3 fish (Sacramento sucker) and using the ratios derived above:

0.139 mg/kg (the safe whole diet Hg concentration) =	(0.10 x 0.50 x TL3conc) +	(Omn. birds)
	(0.05 x 1.17 x TL3conc)	(Pisc. birds)

0.139 mg/kg (the safe whole diet Hg concentration) =	(0.05 + 0.06) x TL3conc	(all birds)

TL3conc = 0.139 / 0.11 = 1.26 ppm
TL4conc = 1.26 x 2.34 = 2.95 ppm

The concentrations found to be protective of people and bald eagles are well below these levels.

Aqueous Concentration Calculations

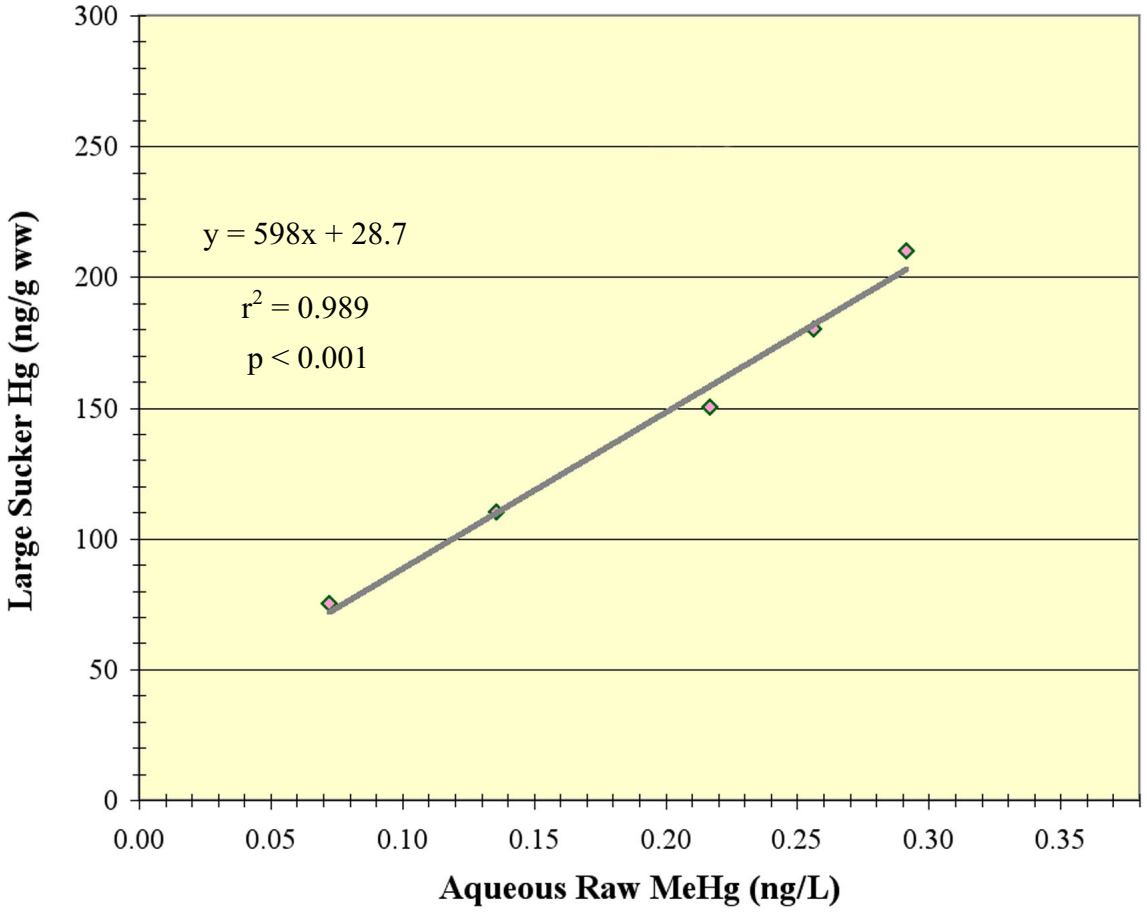
In other portions of the TMDL and Staff Report documents, fish tissue-based target criterion levels are converted into equivalent methylmercury concentrations in Cache Creek water. There are two alternative approaches to making this linkage. The Board has taken an approach that utilizes two independent sub-relationships: (1) that between aqueous methylmercury and small fish or invertebrate methylmercury and (2) that between invertebrate or small fish methylmercury and corresponding mercury levels in large fish. These were the two major relationships that UC Davis was tasked with investigating in the Cache Creek watershed in the Calfed project. The research was successful in identifying useful predictive relationships at each of the two levels. The Board has taken the two relationships and combined them into a single relationship that is intended to span the entire ecological distance between water and large fish. With this technique and additional considerations, the Board has derived aqueous methylmercury concentrations intended to be equivalent to and predictive of corresponding mercury levels in the edible tissues of large, angling-sized fish. The resulting aqueous methylmercury concentration targets presented were 0.06 and 0.07 ng MeHg per liter, corresponding to Alternatives 2 and 3.

A second approach has been developed by the UC Davis team that conducted the original research. This alternate approach was developed partly to test the validity of the 2-step multiplier technique, recognizing that the combining of two separate relationships, each with its own inherent variability and uncertainties, may exponentially lead to unacceptably large levels of uncertainty in the resulting combined relationship. The Cache watershed offered a novel opportunity to conduct such a test, because of the range of aqueous methylmercury exposure levels and corresponding fish mercury concentrations across the watershed. In a "pooled data" approach, the large fish from each independent site could be correlated with the mean annual aqueous methylmercury concentration, which was carefully determined to be representative of average conditions that the fish were exposed to. The water collections for the project were in fact conducted specifically at timings intended to be most representative of average seasonal conditions, as opposed to unusual spike events etc. Because of the substantial range of aqueous and fish methylmercury levels among the different watershed sites, it was possible to generate a direct relationship between mean annual aqueous methylmercury and large fish tissue mercury, a direct alternative to a two-step mathematical estimation. This was done for both large TL4 fish and large Sacramento Suckers (TL3). The results were very similar; the aqueous:sucker relationship was most robust due to more data points. It is presented below in Figure 1.

The relationship reproduced in Figure 1 is statistically highly significant. It demonstrates a direct correlation between average annual methylmercury concentrations in water and corresponding levels in adult fish edible tissue. It shows the actual existing relationship between water and fish across the entire main stem of Cache Creek, including the North Fork. In Figure 2, various potential TL3 fish tissue criterion levels are superimposed on the relationship to show the aqueous methylmercury concentrations that directly correspond to those tissue levels.

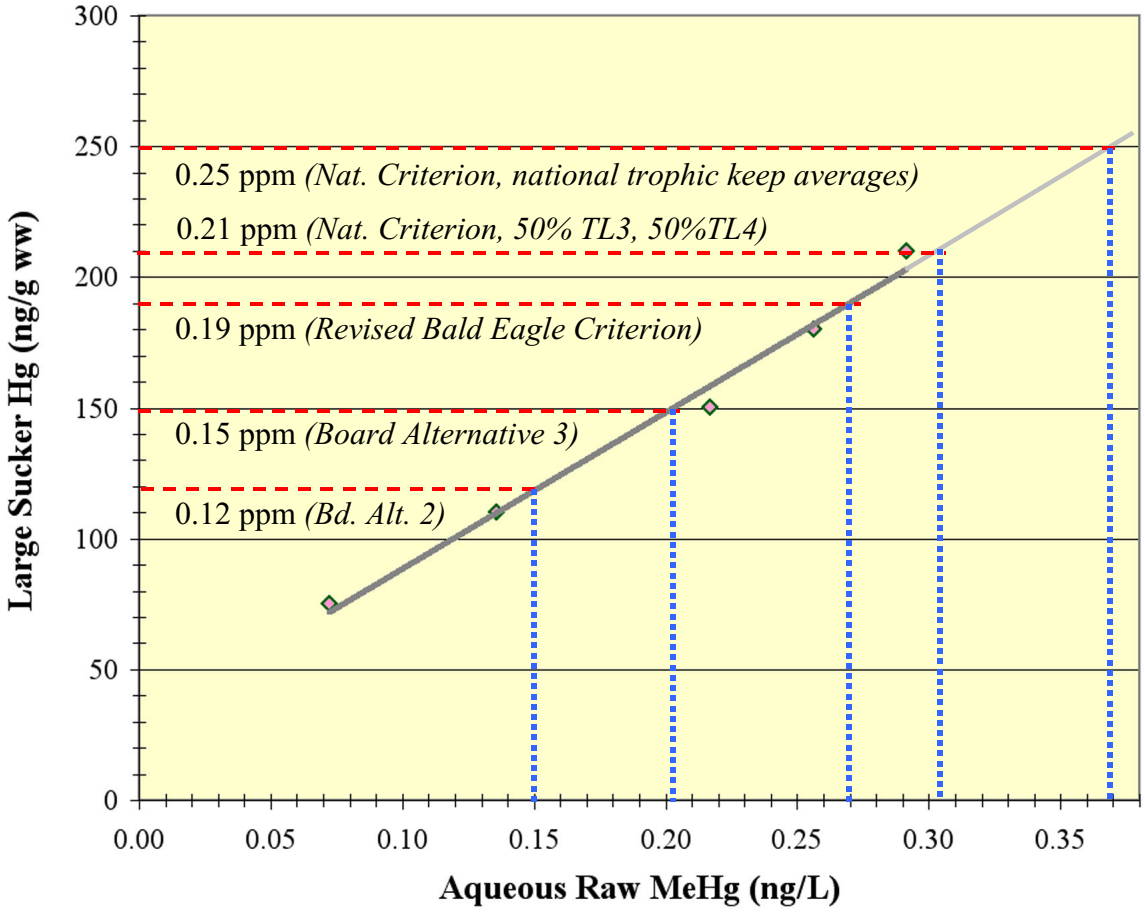
It can be seen that the proposed Alternative 2 TL3 fish target concentration of 0.12 ppm corresponds to app. 0.15 ng aqueous methylmercury per liter, as compared to the 0.06 ng/L level predicted by the other approach. The Alternative 3 TL3 fish target concentration of 0.15 ppm corresponds to approximately 0.20 ng aqueous methylmercury per liter, as compared to

Fig. 1. Relationship between mean annual aqueous methylmercury concentrations and corresponding tissue mercury concentrations in adult Sacramento suckers in the Cache Creek watershed. Including all main stem and North Fork locations. Sacramento sucker tissue mercury normalized to 290 mm fish size for inter-site comparison. From UC Davis CalFed research.



the 0.07 ng/L level presented. The revised TL3 fish criterion target levels derived above in this memo for the protection of human health and the health of federally listed wildlife correspond to aqueous methylmercury concentrations ranging from 0.27 to 0.37 ng methylmercury per liter.

Fig. 2. Relationship between mean annual aqueous methylmercury concentrations and corresponding tissue mercury concentrations in adult Sacramento suckers in the Cache Creek watershed, as before, with various potential TL3 fish mercury criterion levels superimposed, together with corresponding aqueous methylmercury concentrations. Adapted from UC Davis CalFed research.



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